

A Review of IoT-enabled Smart Street Light Power Management Systems: Challenges and Opportunities

Mayuri Kathe^{1*}, Sushil Bakhtar²

Abstract

In the contemporary world, people expect all their demands to be satisfied. To address this human desire, scientific and technological developments are accelerating. One important factor in the quick development of technology is the Internet of Things (IoT). The goal of smart led street lighting systems is to create and implement cutting-edge IOT developments for energy-saving street lighting. Automation of street lighting is the best way to reduce electrical power waste since it eliminates the need for manual lighting system operation. This technique adjusts street light lighting by employing a sensor that uses the least amount of electrical energy possible. At night, when an object is identified, streetlights glow brightest; otherwise, they remain in the dim mode. This technique adjusts street light lighting by employing a sensor that uses the least amount of electrical energy possible. At night, when an object is identified, streetlights glow brightest; otherwise, they remain in the dim mode. The real-time updates of street processing are visualised and changes are notified through the usage of the Internet of Things (IOT). This will lower carbon dioxide emissions, power usage, heat emissions, and maintenance and replacement expenses. Via the internet, one can access real-time street light information (ON/OFF Status) from any location at any time. It guarantees outstanding long-term stability and high dependability. Automated systems are more efficient than manual processes. These gadgets can also be reprogrammed to suit our needs.

Keywords: Microcontroller (CC3200), IR Sensor, LDR sensor, bylnk application, LED

INTRODUCTION

An essential component of any expanding community are streetlights. They can be found in the suburbs as well as on all major thoroughfares. Every day, even when no one is nearby, streetlights are turned on full blast from dusk till dawn. Millions of dollars are spent daily on these streetlights globally to supply the necessary electrical energy. The automated streetlight control system that uses the Internet of Things aims to save energy by cutting down on wasted electricity and labour. Although they provide safer roadways, improved night vision, and increased visibility of public spaces, streetlights are an

essential component of any city, even if they use a significant amount of electricity. Even in situations where there is ample light, the manual streetlight system operates at maximum intensity from dusk till dawn. You may prevent this waste of electricity by having lights turned off on their own. Energy that is saved can be effectively used for a variety of various uses, including residential, business, and transportation. An IOT-enabled streetlight management system can help with this. The greatest way to reduce electrical power waste is provided in this paper. Additionally, the lighting system no longer requires manual activation. Due to population increase, economic expansion, and the tragically limited supply of energy sources, the

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world's energy consumption is rising at the quickest rate ever. We refer to the system as "smart" since it not only powers the streetlights but also assists in determining the direction in which a pedestrian is moving and provides him with assistance by lighting his path until it approaches the next streetlight. Dimming the lights during off-peak hours would be an easy and efficient way to deal with this. When presence is detected, the surrounding lights will illuminate in the regular (bright) mode. This would lower energy consumption as well as the streetlights' operating expenses. Using the Internet of Things (IoT), we may use any location to check the real-time status of streetlights and address any problems that may arise while the data is being processed. One of a city's biggest energy expanses is the streetlights. The cost of municipal street lighting can be reduced by 50% to 70% using a street lighting system. The primary goal of the research is to use sensors to detect light intensity. Based on a real-time system, the streetlight's ON/OFF status will be accessible via the internet at any time and from any location. The control system may be operated in both auto and manual modes. It can turn the lights on and off at the appropriate times and adjust the streetlight's intensity to suit the situation.

OBJECTIVE

One of the smart applications that demands significant energy expenditures in order to establish a smart city infrastructure is the street light control system. There is no doubt that the cost of street lighting can be reduced with the use of a sensible management strategy. The need for energy conservation and upkeep has led to the creation of cutting-edge technology that enables substantial power savings, the highest level of environmental respect, and a decrease in traffic accidents. It reduces the manpower. The Saved energy can be utilized in various purposes like residential, commercial etc. This is done by using the LDR sensor. Here the LDR sensor is used ON-OFF the streetlight based on the ambient intensity level.

RELATED WORK

Mishra et al replaces the energy-hungry conventional HID bulbs with Light Emitting Diodes (LEDs), which don't require a lot of electricity.[1] The system is mainly designed to ensure safety and to prevent energy wastage. Nagamani et al outlines a novel solution to the major accidents and street light system problems. It was made of wireless technology that adapts to the weather and can be managed by a base server by just sending information.[2] Dheena et al replaces the energy-hungry conventional HID bulbs with Light Emitting Diodes (LEDs), which don't require a lot of electricity. Intensity variation is made possible by LED lights with LDR, something that is not possible with HID lamps. Because LEDs are directed light sources, they may generate light in a particular direction, which maximises streetlight efficiency. [3] An Arduino UNO-based voice-controlled smart traffic (VCST) system with traffic-flow-based smart (LED) streetlights and the ability to monitor the system through the use of particular voice commands was proposed by Biswal et al. It provided low-cost, extremely dependable, and user-friendly smart grid architecture with a low-power ZigBee network, as well as energy optimisation techniques. They run the system with basic verbal instructions like stop, red, green, and yellow.[4] The idea behind Yusoff et al.'s smart technology is to create an intelligent system that uses an infrared sensor module to detect movement and determine whether to turn on or off the streetlight. The Arduino Mega 2560 microcontroller, which receives the data, will determine whether to switch on or off a roadway light. [5] Using Bhavadeesh's method, users may manually control the light by varying its brightness from anywhere in the world using a laptop or mobile device, and they can also find out how long a lightbulb will last. In response, emancipate current rate primarily, maintain the utility viability of streetlights and personal property, and subsequently redeem labour value of commodities and subsistence.[6] Anitha et al.'s paper is mostly used for smart and climate-adaptive lighting in streetlights. In the late afternoon, the streetlights turn on immediately, and in the daytime, they turn off automatically. Through the internet, one can turn on or off a roadway light at any given moment or place. [7] In the work of Kodali et al, the notion of developing a flexible smart city management plan which is crucial to the affluent lives of future generations living in urban environments is put out, along with smart street light design, which is one of the fundamental principles in decreasing electricity waste.[8]

PROPOSED SYSTEM

The automated streetlight control system that uses the Internet of Things aims to save energy by cutting down on wasted electricity and labour. Although they provide safer roadways, improved night vision, and increased visibility of public spaces, streetlights are an essential component of any city, even if they use a significant amount of electricity. Even in situations where there is ample light, the manual streetlight system operates at maximum intensity from dusk till dawn. You may prevent this waste of electricity by having lights turned off on their own. Energy that is saved can be effectively used for a variety of various uses, including residential, business, and transportation. An IOT-enabled streetlight management system can help with this. We utilise the LDR's characteristic that its resistance changes in proportion to light intensity in our suggested solution as shown in block diagram of Figure 1. Our suggested solution uses an LDR to distinguish between day and night. Streetlights are then automatically turned on and off during the day and on during the night. An IR sensor is utilised to detect the presence of vehicles on the road. The IR sensor will detect if there are less people in the street and turn on the lights if the car is in the street; otherwise, it will turn on the lights. India is among the emerging nations that are having problems with energy availability and a lack of power supplies as a result of their constantly growing population. An over reliance on fossil fuels can lead to issues that threaten the survival of future generations. To combat the energy crisis in the current environment, it is crucial to understand how to reduce energy consumption and how to adopt different energy-efficient strategies, at the very least, for power-limited systems. Many studies are conducted, and people are trying to find a better, more sustainable answer for the coming generations. An energy-efficient management system now has a new dimension thanks to the Internet of Things. The issues with energy waste that currently exist can be mostly resolved by the Internet of Things.

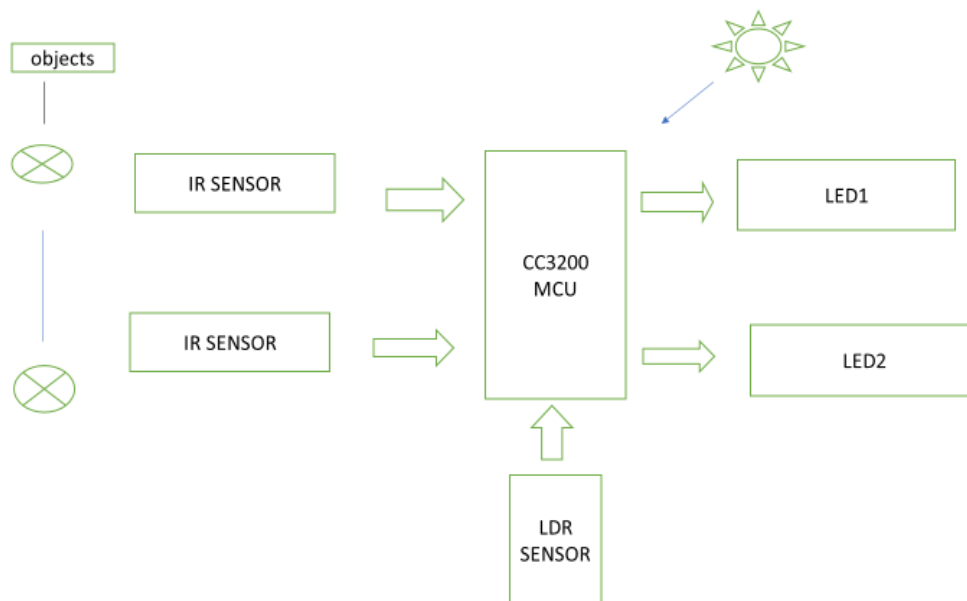


Figure 1. Block diagram for Smart Street Light System Using IOT.

HARDWARE

A Microcontroller (CC3200)

The CC3200 device is a full platform solution that comes with user and programming guides, reference designs, software, tools, and the TI E2ETM support network. This subsystem has a MAC with a strong crypto engine, baseband, and an 802.11 b/g/n radio for quick, safe Internet connections with 256-bit encryption shown in Figure 2. The first single-chip microcontroller unit (MCU) with integrated Wi-Fi connectivity to receive Wi-Fi certification. Customers can create an entire application with a single integrated circuit (IC) by using the Simple Link CC3200 device, a wireless MCU that

includes a high-performance ARM Cortex-M4 MCU, designed for the Internet of Things (IoT). [9] Faster development is possible because on-chip Wi-Fi, the Internet, and strong security protocols eliminate the need for prior Wi-Fi knowledge. The CC3200 microcontroller is a full platform solution that comes with programming and user instructions, tools, programmes, and reference designs.

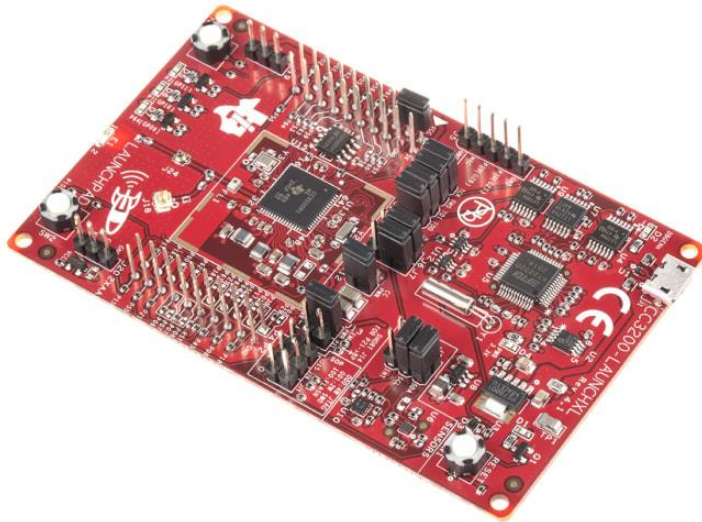


Figure 2. Microcontroller (CC3200).

IR Sensor

An electrical gadget called an infrared sensor emits light to detect certain elements of its environment. In addition to detecting motion, an infrared sensor may measure an object's heat. An infrared sensor functions similarly to an object detection sensor shown in Figure 3. This sensor has an IR LED and an IR photodiode, which when combined can create an optocoupler or photo-coupler. It draws less energy. Both in the presence and absence of light, motion can be detected roughly with comparable reliability. They can detect an object without encountering it. The beam direction ensures that no data leaks.

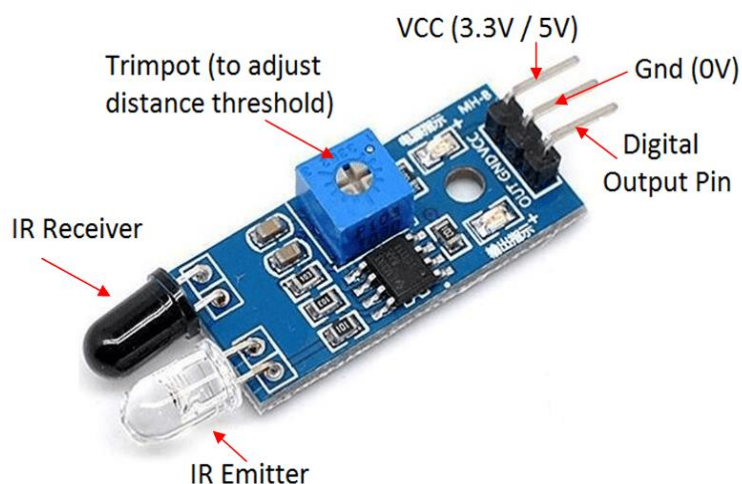


Figure 3. IR Sensor.

LDR Sensors

Another name for an LDR (light dependent resistor) is a photo resistor shown in Figure 4. These gadgets are reliant on light. When the light falls on the LDR, the resistance will decrease, and at this point, the resistance level is low. The resistance grows and reaches a high degree when the LDR is

placed in a dark area. An apparatus whose resistance depends on the electromagnetic radiation that is incident is called a photo resistor, or LDR. They are therefore light-sensitive gadgets.

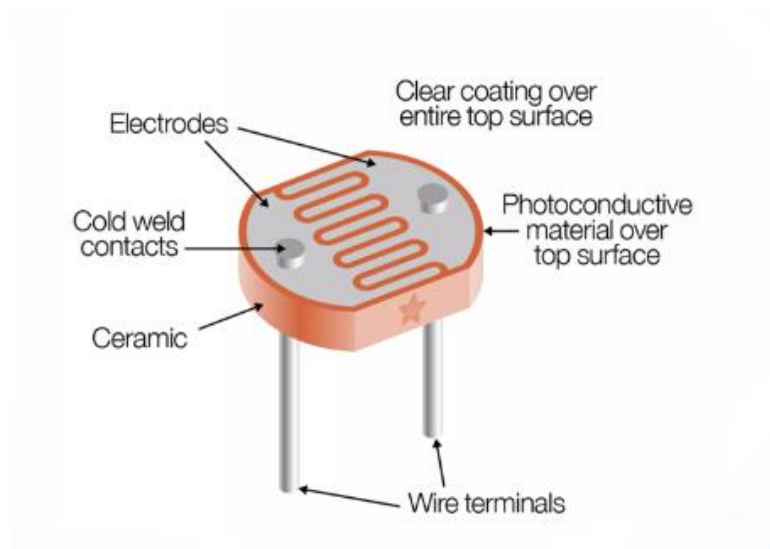


Figure 4. LDR Sensor.

LED

A semiconductor device known as a light-emitting diode (LED) shown in Figure 5 releases light when an electric current passes through it. An LED emits light when current flows through it because the electrons recombine with the holes. LEDs permit current to flow in one direction while blocking current flow in the other. P-N junctions with heavy doping are used in light-emitting diodes. When forward biased, an LED will produce coloured light at a specific spectral wavelength depending on the semiconductor material and doping level. An LED is encased in a transparent cover, as seen in the figure, to allow light to be released.



Figure 5. LED.

IMPLEMENTATION OF THE METHODOLOGY

The term "Internet of Things" refers to the concept of creating new avenues for interaction between electronic devices through digital interfaces, potentially offering information in an easy-to-use format to smart gadgets that are connected to the same network as the rest of the system. Every device in this system must function on the Internet of Things and be connected to other devices over the same network. With a CC3200 microcontroller, IR sensors, LEDs, and an LDR sensor, the system design is adaptive. The CC3200 microcontroller serves as the system's central nervous system in this one. The

micro controller in this system is connected to every sensor that is used as shown in Figure 5. Its resistance lowers and the light turns off when it is exposed to daylight during the day. Because there is less light hitting the sensor at night, its resistance rises and the light turns on. The infrared sensor functions as both an electromagnetic and automated switch when it is linked to the microcontroller. It turns the lights on and off automatically and is quite dependable.

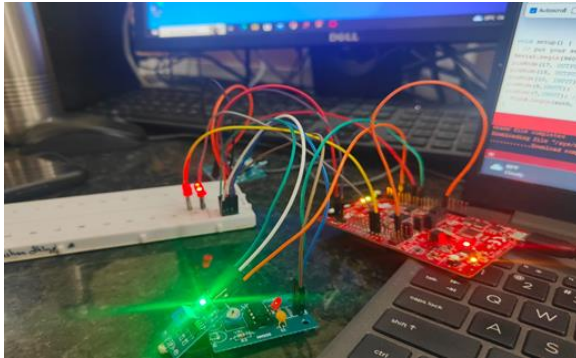


Figure 6. Working of Smart Street Light system.

BLYNK APPLICATION (BLYNK IOT)

The Blynk Server oversees managing all communication between hardware and smart devices as shown in Figure 7.

Blynk Libraries

They process all incoming and outgoing commands and allow communication between the server and all popular hardware platforms. When a user hits the button in the Blynk application, data is transferred to the Blynk Cloud and then somehow makes its way to the installed equipment.

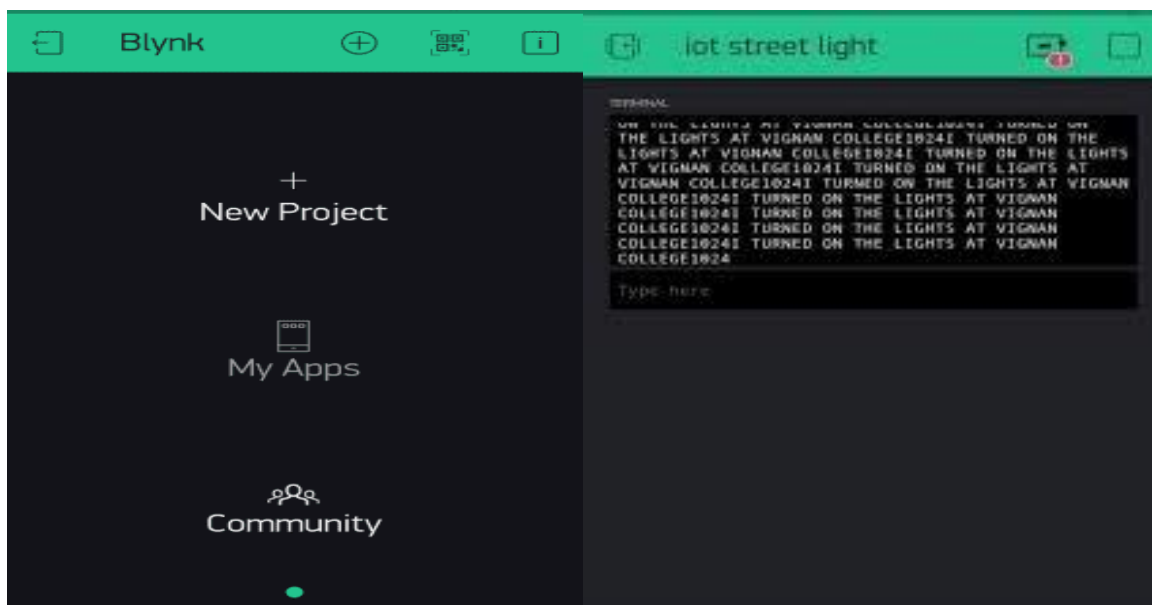


Figure 7. Blynk Application.

RESULT

The project's objectives were to discover a way to save power and lessen the negative consequences of the current lighting system. Setting up the system's inputs and outputs to control the lights is the first step in this project. The project depicted in the image has been carried out, functions as anticipated, and will be extremely beneficial.

CONCLUSION

Power electronics are becoming more and more prevalent in all spheres of human endeavour. When compared to the current system, the suggested method is simpler to set up and operate and requires less maintenance. We examine how quickly IoT has evolved to integrate with our daily lives. One of the main components that makes use of IoT technologies is the smart street light system. The Smart Street Lighting System effectively addresses the primary issues, such as energy waste, crime detection, incandescent light disposal, maintenance costs, etc. This method protects people against harassment by women, break-ins, and further intimidation by ensuring traffic safety and security. Because 50–60% of electricity is saved and employed for other significant uses, the energy crises that occur in cities may be lessened. This technology produces a safe atmosphere and may be fully adjusted to meet the needs of users. This method uses straightforward software and minimal hardware. Decisions about streetlights were made by the system, so human operators' negligence could be avoided. It will be useful in transforming our city into a smart city as well. The most economical, environmentally responsible, and secure method to save energy and lower costs is to undertake this project.

Future Enhancement

Not only does this Smart Streetlight initiative benefit rural communities, but it also benefits urban areas. Our need for power is increasing as we move towards greater technology, and using renewable energy is favourable and helpful. This idea even allows us to add smart parking to a car, which is helpful for driverless vehicles. This technology has a promising future because it would not only save electricity but also lessen disasters and even lower the crime rate.

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